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Instructional lecture

Lessons from the past: pathways to the future

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Introduction

A famous American surgeon, A. Bruce Gill, once said "Study principles, not methods. A mind that understands principles can devise its own methods." Here I discuss 10 basic principles in the field of spinal deformity treatment that have strong messages from the past and apply equally to the future.

Principle 1: Progressive curves must be stopped by bracing or surgery — there is no excuse for procrastination

That spinal curves must be stopped from progressing by bracing or surgery is a very old principle, and we should not even have to mention it in this era, but the problem still exists. Sometimes the problem lies with the general practitioner who does not understand the seriousness of a child with a unilateral unsegmented bar and fails to refer the child promptly to a spine specialist. Only when the curve has progressed severely does the referral come, and then it is too late. This is a problem of educating our medical colleagues.

Sometimes the problem is with the spine surgeon who either fails to recognize the serious nature of the problem or fails to measure the films carefully to detect the progression. Sometimes there is simply a reluctance to operate on a 1-year-old child for fear of "stunting the child's growth." Letting a curve progress severely gives far more torso shortening than would early fusion.

Principle 2: Just because it is new does not mean it is good

We as medical practitioners have a tendency to jump onto a new treatment idea without giving it adequate thought and especially without looking at it using a true scientific approach. This is not as bad a problem as it used to be, but it still exists. The main reason seems to be a reverence for our mentors and teachers. By this I mean that when a distinguished member of our profession states, "I've been using this treatment for some time and it is really good" we accept it blindly and do not test it scientifically before using it on our patients. An excellent example is the historical enthusiasm for exercises in the treatment of scoliosis. Exercises were promoted for hundreds of years by "learned" professors but in reality have been proven useless. We are now seeing a resurgence of interest in exercise therapy but again without any scientific proof whatsoever.

The list of treatments that we have "jumped on" without good evidence is quite long, so I mention only a few. Electrical stimulation of the paraspinal muscles was a hot topic during the early 1990s but proved to be useless. The Halo-pelvic device, first introduced in Hong Kong in 1963 and later in Chicago, was used on hundreds of patients but was a disaster with little benefit and many complications. Gruca springs (Poland, 1958) were proven useless. The Wenger device (New York, 1961) was equally useless and even more dangerous. Cotrel traction for 2 weeks prior to surgery sounded good but turned out to be useless (preoperative traction for curves is discussed in more detail later). Stapling of the convexity was tried and abandoned during the 1950s but has emerged once again.[1]

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Principle 3: There is more than one way to correct a scoliosis, and it is the wise surgeon who knows when to use each approach

If we can look at a lateral curvature of the spine as an engineer and not be prejudiced by the latest fad of instrumentation, we can see that several corrective mechanisms are available. The first is simple concave distraction. A Harrington distraction rod best illustrates this in the concavity of the curve. Another mechanism is simple convex compression. This is best illustrated by a purely compressive implant for a Scheuermann's kyphosis.

Back in the "old" days of cast correction, we used the Risser localizer cast, which used longitudinal distraction, coupled with a convex localizer force, a translation force. This method was introduced during the early 1950s but was done in exactly the same way by Wullstein in Germany during the 1880s.

Harrington frequently combined a concave distraction rod with a convex compression rod, using two different forces to achieve correction plus stabilization. The convex compression rod was a form of segmental fixation.

Luque introduced a whole new concept — that of cantilever correction when applied to the convexity of a curve. There was no distraction and no compression. A Luque rod in the concavity corrected the deformity by translation, the wires pulling the apex of the curve to the midline.

Cotrel and Dubousset, during the early 1980s, introduced us to correction by rod rotation. This was originally conceived as a "derotation" maneuver but in reality was translation of the apex of the curve toward the midline and out of lordosis by rod rotation. Thus, translation was emphasized rather than distraction.

In summary, we can correct by pure distraction, pure compression, cantilever force, pure translation, and various combinations of the above. The introduction of thoracic pedicle screws has added a final maneuver — segmental derotation of the pathological elements.

Principle 4: Correction of thoracic lordosis is best accomplished with sublaminar wires and kyphotically contoured stiff rods

Whether a pure lordosis or a lordoscoliosis, the mechanism needed for correction is direct translation of the affected vertebrae out of the lordosis into a normal sagittal alignment. The problem is how do we achieve it? Distraction lessens the lordosis but cannot create kyphosis. Compression worsens the deformity, and cantilever forces cannot be used.

For the pediatric or adolescent patient, the best method is the use of sublaminar wires, pulling the spinal elements directly backward. Radical excision of the ligamentum flavum, necessary for passing wires, is also a major release of the contracted elements. It is coupled with complete excision of the facet capsules. The rods must be stiff, or the rod will be flattened, defeating the purpose of the procedure. The best rods are "cold-rolled" stainless steel, which is stiffer than ordinary spinal steel. Titanium is too soft a metal to accomplish this goal. Dual rods are best with separate sets of wires for each rod. The tightening begins at each end, working toward the center. It usually takes several passes before the apex of the lordosis finally reaches the rod. This is one situation where pedicle screws are virtually useless.

The patient in Fig. 1 illustrates this principle.

Principle 5: Correct the primary curve and let the compensatory curve balance itself

Back in 1949, Von Lackum told us that we surgeons must analyze carefully each of the curves as to their magnitude and their flexibility and that we should not overcorrect the primary curve beyond the ability of the secondary (compensatory) curve to balance the spine.[2] This was during the era of cast correction; and now in our era of powerful internal devices, we must be careful not to repeat the same mistake.

There are two main areas where this is a problem. The first is the high, left upper thoracic curve above a typical right thoracic scoliosis. This short curve can have various degrees of flexibility (rigidity), which must be carefully analyzed before surgery. When it is quite stiff, as evidenced by a well-done bending film, it is a double primary curve situation (King-Moe 5, or Lenke 2), and both curves must be included in the fusion. If they are not, a vigorous correction of the right thoracic curve will result in lifting of the left shoulder.

If this high left curve is very flexible, the surgeon can proceed to correct the right thoracic curve without concern for shoulder imbalance. The problem is the high left curve, which has intermediate flexibility. This is the curve we would like not to fuse, but we must use constraint when correcting the right thoracic curve.

The more common problem is the left lumbar curve below the right thoracic curve. When it is just as large *and just as stiff* as the right thoracic curve, it is a double primary pattern (King-Moe 1, Lenke 3), and both curves must be fused. When this curve is small and very flexible (King-Moe 3, Lenke 1A), there is no problem; and one can fuse the right thoracic curve without concern.

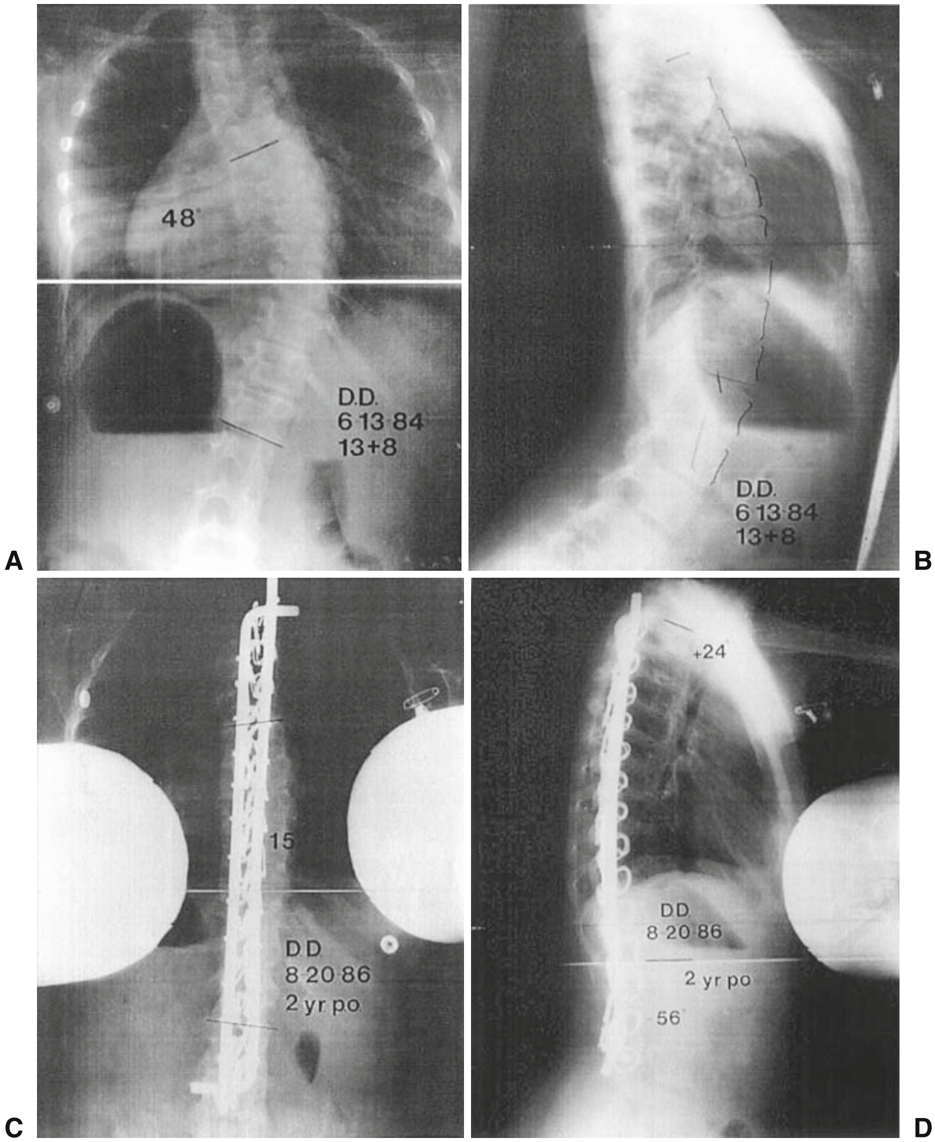


Fig. 1. a This 13-year-old adolescent had 48° thoracic scoliosis. **b** More important, she had –26° thoracic lordosis. **c** With Luque instrumentation and fusion, her scoliosis was corrected to 15°. **d** More important was the correction of her lordosis to +24°, a 50° correction in the sagittal plane. She underwent no anterior procedure and no rib or transverse process procedure

The issue is the common situation of a lumbar curve that is as large or almost as large as the right thoracic curve but is much more flexible on the bending films (King-Moe 2, Lenke 1C). Because of the size of the curve and the rotation seen on the standing film, many surgeons are tempted to extend the fusion down into the lumbar curve. This is a mistake, as this lumbar curve will spontaneously correct itself to balance the residual thoracic curve. It makes no difference how the thoracic curve was treated (anterior, posterior, hooks, screws, hybrids); the lumbar curve will balance so long as the thoracic curve is not overcorrected. The Lenke 1B curve pattern should be abandoned, as it does not aid in the selection of the fusion area, as not all of these curves need the lumbar curve to be fused.

The patient in Fig. 2 illustrates this principle

Principle 6: Traction does not "soften up" a curve; it merely shows you the true flexibility of a large curve

During the 1980s, Cotrel advocated the use of 2 weeks of preoperative traction using a head halter and pelvic bands, stating that such traction "softened-up" the curve, allowing greater correction during surgery. This program was widely adopted around the world — with no scientific evidence to support its use.

When subjected to scientific analysis, patients undergoing traction did not have any better correction at surgery than those who did not undergo traction.[3] This was a classic example of our listening to the "expert" without applying the scientific method. What about more vigorous forms of traction, such as halo-femoral traction for very large curves?

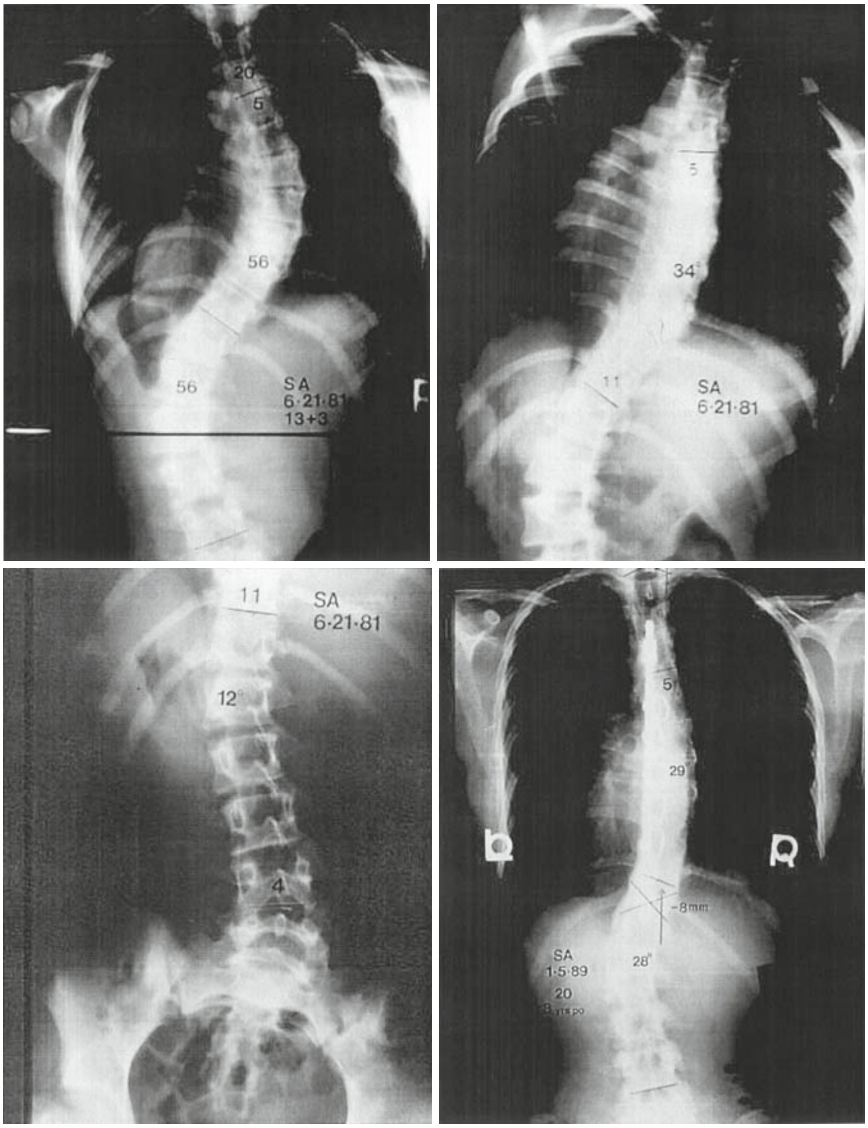


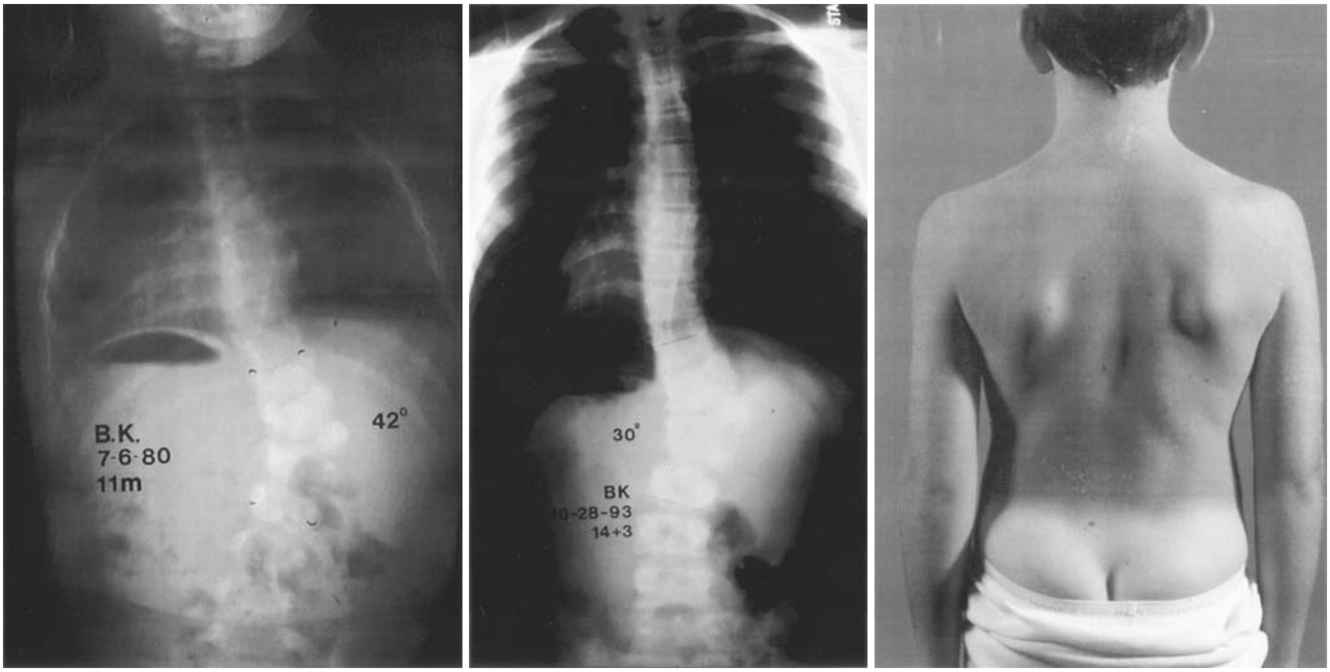
Fig. 2. a. This 13-year-old girl had two 56° curves. Do both curves need surgery? **b** Supine voluntary side-bending film of the thoracic curve showed correction to 34°. **c** Supine bending film of the lumbar curve showed correction to 12°, a marked difference. **d** A film obtained 8 years after her selective thoracic fusion shows both curves to be about 28° after Harrington-Luque instrumentation

During the 1960s, Moe began using halo-femoral traction for very large or very stiff curves. This was usually a 2- to 4-week program of gradually increasing weights until no further improvement was seen on periodic radiographs. One patient had her 100° postpoliomyelitis curve corrected in traction to 25° in just 2 weeks. She was scheduled for surgery, but it had to be postponed owing to a viral infection, so she spent another month in traction. Her curve did not improve a single degree in those four additional weeks of traction, which made us begin to doubt the effectiveness of this treatment.

We thus set up a small experiment wherein we did the usual standing, supine, and supine bending films. We then put the patient on the Risser/Cotrel casting table and pulled very hard plus adding a localizer strap to the convexity of the primary curve. A radiograph was then obtained, establishing the "true" flexibility of the curve. This was always a value better than the bending film. We then applied halo-femoral traction for 3 weeks, obtaining a radiograph weekly. After 3 weeks, the curve was always the same as the curve on the casting table film.

Pinto, of Sao Paulo, Brazil, analyzed 150 patients placed in halo-femoral traction for very large curves, mostly after poliomyelitis. He found that once a short-radius curve was corrected to a long-radius curve, no further correction occurred. This study was presented to the Scoliosis Research Society in 1974 but was never published.[4]

Is halo traction useless? No, because there is a specific indication for it that is still valid today — in the patient who presents with a very large thoracic curve and whose pulmonary functions are so bad as to make surgery highly dangerous or impossible. In such situations, halo-gravity traction can result in such a great improvement



A B,C

Fig. 3. **a** This 1-year-old boy had 42° congenital scoliosis due to a hemivertebra at L1. Should it be removed? **b** At age 14, the curve was 30°. He had received no treatment of any kind. **c** A photograph at age 14 shows almost no deformity. Of interest is that he is one of identical twins, and his twin brother has no anomaly of the spine

in vital capacity and blood gases that surgery can then be safely done.[5]

Principle 7: Not all hemivertebrae need excision

There is an alarming situation developing in which the surgeon sees a child with congenital scoliosis, and at the apex of the scoliosis is a hemivertebra. Surgery is immediately scheduled for a hemivertebra excision that is to be done through a posterior approach.

This is wrong. There are many types of curve that contain one or more hemivertebrae, and even different types of hemivertebrae. One situation is a spontaneously improving curve situation where the treatment is observation alone. We have seen four such patients at our center, and none of the four ever needed surgery.

At the other end of the spectrum is the fully segmented hemivertebra at L5. These hemivertebrae are notorious for causing progressive decompensation with a very large secondary curve if left untreated. The optimal treatment is excision at an early age. Hemivertebrae that cause fixed truncal decompensation require excision as there is no other way to achieve trunk balance. Hemivertebrae at the thoracolumbar junction or in the thoracic spine can be better managed by convex hemiepiphyseodesis/hemiarthrodesis surgery — which is slow to achieve correction but much, much safer.

Although we know that "posterior-only" hemivertebra excision can be done, we prefer the safer combined anterior/posterior approach as it also allows us to perform epiphyseodesis surgery above and below the hemivertebra if needed.

The patient in Fig. 3 illustrates this principle.

Principle 8: Early fusion can be good

What do we do with the child born with severe congenital scoliosis that progresses during the first year of life? It is almost always caused by a unilateral unsegmented bar with or without a convex hemivertebra. As shown by McMaster and Ohtsuka and others, these curves progress at a rate of 5°–10° per year. Thus, if a child has a 60° curve at birth, it will be at least 85°–110° by age 5 years. By this time major damage has been done to the lung capacity, and correction is extremely difficult.

The traditional answer to such a problem was prompt fusion surgery, both anterior and posterior, at about the age of 1 year. Anterior surgery was needed because the growth plates on the convexity, the ones responsible for the progression, are anterior. Epiphyseodesis surgery would not work because there are no growth centers in the concavity to cause progressive improvement.

What about the effect of a major fusion of the thoracic spine in a 1-year-old child? Would we not be causing severe shortening of the torso? Would we be

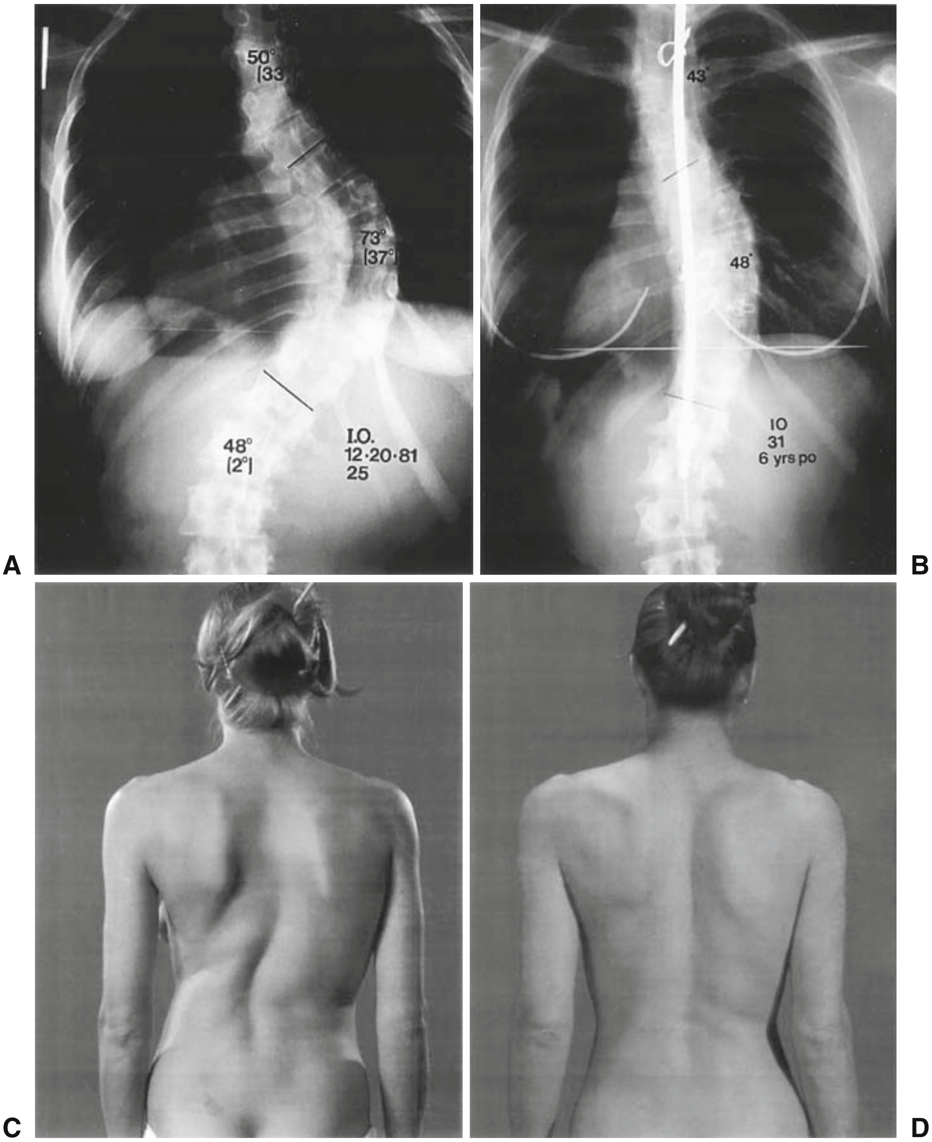


Fig. 4. a This 25-year-old female medical student presented with a triple curve pattern. The high left thoracic curve was 50°, correcting to 33° on the bend film. The right thoracic curve was 73°, correcting to 37° on the bend film. The lumbar curve was 48°, correcting to 2° on the bend film. This lumbar curve is obviously a purely compensatory curve and does not require surgery. The two thoracic curves (King-Moe type 5 or Lenke type 2) both require surgery. **b** She had a single Harrington distraction rod across both thoracic curves plus a few Luque wires. She wore a brace for 6 months following the surgery. This film, obtained 6 years after surgery, shows the high left curve at 43° and the right thoracic curve at 48°. **c** Preoperative photograph. **d** Her 6-year postoperative photograph. Note the perfect balance that has been achieved. Her shoulders are level, and her head and thorax are perfectly centered. She is now, 26 years after surgery, a successful emergency room surgeon in a large American city. Although the correction of her major right thoracic curve was only 34%, the result is perfect. Maximum correction is not always the optimal correction

causing a major pulmonary problem? These are all good questions but must be answered scientifically, not emotionally.

Yes, the fused area will not grow vertically. However, preventing a major curve increase results in a short trunk but one *that is longer than would have occurred if the fusion had not been done.* By early fusion we are preventing progressive loss of lung function and early death due to cor pulmonale. The few cases of such early surgery with follow-up into adult life have shown highly positive results, far better than allowing curve progression.[6,7]

There is a new procedure, osteotomy of the fused ribs in the concavity of the curve and insertion of a vertical rib distraction device, developed by Campbell and colleagues in Texas.[8] The rib distraction, periodically lengthened, is designed to create a far better concave lung space and to stop curve progression or even alleviate the curve. So far these procedures appear to be doing well, but none of the patients has reached the end of growth. Unfortunately, few pulmonary function tests have been done; only computed tomography scans of the chest volumes are available.

Principle 9: Instrumentation without fusion can be effective

Instrumentation without fusion with periodic lengthening has been with us since 1970. It is not something new. It is designed for the young child with a curve too large for brace treatment but a curve flexible enough to have major improvement with distraction. Because the concept is to maintain curve control while permitting vertical torso growth, there must be viable growth tissue in the concavity of the curve, which rules out most congenital scolioses. Thus, its primary use has been with infantile and juvenile idiopathic scoliosis and syndromic scoliosis.

We began doing this procedure in 1975, the first patient being a 4-year-old girl with an 84° curve related to congenital muscular hypotonia. Since then we have performed the surgery in more than 100 patients with mixed results.[9] Our initial patient was fused at age 10 and was followed to the end of growth. Both goals were achieved. Her final curve is 50°, and her torso length is normal.

Recent studies have shown that a dual distraction rod system is better than a single rod system, that lengthening is needed on a regular basis (every 6 months), and fusion should be done whenever curve control is lost or no further torso lengthening is being accomplished.[10] Fusion usually takes place at the pubertal growth spurt as curve control is usually lost then and the curves become so stiff that correction fails.

Principle 10: The ideal end result of our surgery is a spine balanced in both the frontal and sagittal planes, *not* the maximum correction

As various implant systems have been developed, we as surgeons have become obsessed with "percent correction." When all we had was a Risser localizer cast, the average final correction of typical thoracic idiopathic scoliosis was about 40%. When Harrington instrumentation was introduced, the average correction increased to about 45%. For a 60° curve, this meant a final curve of 36° with a cast, and a 33° curve with the rods, not a significant difference. With Cotrel/Dubousset instrumentation or the many other hook-rod systems, the correction improved to about 55% and with pedicle screw systems to about 65%. This meant a final curve of 27° and 21°, respectively. Thus, the final result is a better Cobb measurement number, but does this mean a healthier, happier patient?[11]

When our enthusiasm for more correction of the primary curve results in a decompensated patient, our goals of good patient care have been violated. A long time ago the French philosopher Voltaire said, "The enemy of good is better." More recently, in his Harrington Guest Lecture to the Scoliosis Research Society, Dubousset said, "The maximal correction is not the optimal correction." We must look at the whole patient, and not just at the Cobb X-ray measurement (Fig. 4).

Conclusions

There are many principles from the past that apply to the future. I have chosen 10 of them that I believe to be important. When I hear doctors discussing exercises for scoliosis, I am discouraged, as this method has long been proven to be useless by many researchers. When I hear surgeons discussing the benefits of halo traction for "softening-up" a big curvature, I am discouraged. These surgeons have not researched the earlier literature, nor have they consulted with those "old" surgeons who went through those trials years ago. I plead for not adopting new methods until their value has been proven scientifically, especially by someone who is not the inventor. Finally, I plead for us as surgeons not to be seduced by "percent correction" mania.

The patients and/or their families were informed that data from any cases would be submitted for publication and gave their consent.

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